Toxic Metal and Essential Trace Element Levels of Blood Donors

Kan Bağışı Yapan Bireylerde Esansiyel Eser Element ve Toksik Metallerin Düzeyleri

Heavy Metals of Blood Donors

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Özet

Amaç: Kan bağışı yapan bireyler hepatit, sitomegalovirüs gibi değişik patojenler açısından taranmaktadır. Toksik metal düzeylerinin taranması rutin bir prosedür değildir. Bu çalışmanın amacı, maruziyeti olmayan Türk bireylerde demir, çinko ve bakır gibi eser elementlerin ve kadmiyum, kurşun gibi toksik metallerin tam kan düzeylerini saptamak ve kronik metal toksisitesi riski bulunan bireyleri tanımlamaktır. Gereç ve Yöntem: Tam kan kurşun ve kadmiyum düzeyleri grafit fırınlı atomik absorpsiyon spectrometresi ile analiz edildi. Metal düzeyleri 211 erkek kan bağışı yapan bireyin (19-55 yaş arası, 33.71±8.69 yıl) tam kan ve serumlarında çalışıldı. İstatistiksel analiz SPSS v16 ile gerçekleştirildi. Bulgular: Kadmiyum, kurşun, çinko, bakır ve demir düzeylerinin ortalaması sırasıyla 1.27±0.88 µg L-1, 25.1±12.44 µg L-1, 0.97±0.16 mg L-1, 1.10±0.21 mg L-1, 476.53±42.41 mg L-1 idi. Sadece bakır düzeyleri ile yaş arasında istatistiksel olarak anlamlı pozitif korelasyon saptandı (p<0.01). Vücut kitle indeksi ve ölçülen tüm diğer metal seviyeleri arasında önemli bir korelasyon saaptanamadı (p>0.05). Sigara içimi ile kadmiyum düzeyleri istatistiksel olarak anlamlı ilişki gözlendi (p<0.01). Tartışma: Sonuçlar, toksikologlara ve klinik kimyacılara insanların eser element eksikliği veya daha yüksek metal seviyelerine maruziyet hakkında bilgi sağlayabilir.

Anahtar Kelimeler

Kan Bağışı; Metal Toksisitesi; Eser Elementler; Sigara; Vücut Kitle İndeksi

Abstract

Aim: Blood donors are screened for various pathogens including hepatitis and cytomegalovirus. Screening for toxic metal levels is not routine process. The aims of our study were to determine the whole blood levels of toxic metals, cadmium and lead, and levels of the trace elements iron, zinc, and copper, of non-exposed Turkish subjects and also to identify individuals living under the risk of chronic metal toxicity. Material and Method: Whole blood lead and cadmium levels were analyzed by Graphite Furnace Atomic Absorption Spectrometry. Metal levels were determined in the whole blood and serum samples of 211 male blood donors (aged 19 to 55; 33.71±8.69 years). Statistical analysis was performed by SPSSv16. Results: Average levels of cadmium, lead, zinc, copper and iron were found to be 1.27±0.88 µg L-1, 25.1±12.44 µg L-1, 0.97±0.16 mg L-1, 1.10±0.21 mg L-1, and 476.53±42.41 mg L-1, respectively. Donor age had a statistically significant positive correlation only with copper levels (p<0.01). There were not any significant correlations between BMI and any of the measured metal levels (p>0.05). A statistically significant association was found between smoking and cadmium levels (p<0.01). Discussion: Results may provide information for toxicologists and clinical chemists to determine whether people have trace element deficiencies or have been exposed to higher levels of toxic metals.

Keywords

Blood Donor; Metal Toxicity; Trace Elements; Smoking; Body Mass Index

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Introduction

Blood donors are screened for various pathogens including hepatitis, cytomegalovirus, and human immunodeficiency virus (HIV). Screening for toxic metal levels is not part of routine process [1]. However, data related to the level of trace elements and toxic metals in the human body is useful to determine their associations with morbidity and mortality, to identify the amounts required to sustain a healthy state, for nutritional status, and for the implementation of government regulations [2]. Zinc (Zn) and copper (Cu) are essential trace elements that play important roles in many metabolic cell processes [3]. Toxic metals such as arsenic (As), mercury (Hg), cadmium (Cd), and lead (Pb), which are extensively found in the environment, have a toxicological significance and accumulate in living organisms without any degradation or catabolism [4]. The toxic metals and trace elements interact either with molecules in biosystems and/or the other essential metals due to metal exposure caused by environmental pollution. Also, trace elements and toxic metals compete for absorption, dispersion, and accumulation stages in mammalian tissues.

In many countries there have been multiple research studies to determine community exposure to environmental toxic metals, to examine changes over time, and to create reference values [2,5-9]. There is only one study related to blood bank donors and metal levels [1]. Although there are also many studies of various groups to determine possible metal exposure in Turkey, no study has been found that tested healthy groups to detect blood metal levels. Thus, the aim of the present study is to determine both toxic metal (Cd and Pb) exposure and the levels of trace elements (Zn, Cu, and Fe) of individuals in Turkey.

Material and Method

Study Subjects

In this study, whole blood and serum samples were obtained from 211 male donors aged between 19 and 55 years (mean age, 33.71±8.69 years). This study was designed prospectively and ethical approval was obtained from our Institutional Ethic Committee. All participiants were given an informed consent. For metal analysis, 2 mL of venous blood was collected from all donors into tubes with EDTA and plain tubes. Serum was separated by centrifugation and stored at +4 °C until analysis.

Instrumental Analysis

Whole blood Pb and Cd were analyzed by Varian AA 240 Z Graphite Furnace Atomic Absorption Spectrometry (GF-AAS). Serum Zn, Cu, and Fe were analyzed by Varian AA 240 FS Flame Atomic Absorption Spectrometry (F-AAS). 1 ml blood samples were dissolved in 9 mL of nitric acid (HNO3) and transferred to Teflon tubes to be digested in a 1600W Cem Mars Xpress microwave oven at 220 ºC for 10 minutes and were held 5 minutes more in the oven after the procedure was completed. Digested, samples were transferred from microwave test tubes to polypropylene flasks and diluted with deionized water up to 20 ml before the analysis by Atomic Absorption Spectrometry (AAS). All of the samples were stored at +4 oC in a refrigerator. Ultra pure nitric acid and deionized water were used throughout all analyses. All chemicals used were of analytical reagent grade. Standard solutions were prepared from the dilution of 1000 mg L-1 Cd, Pb, Zn, Cu, and Fe stock standard solutions. Concentrated HNO3 was obtained from Merck. Deionized water from Innovation Pure Water System (Human Corporation) was used throughout the study. A Cd, Pb, Zn, Cu, and Fe Hollow Cathode Lamp was used. Absorbance was measured as peak height with specific spectral band. Five replicate measurements were performed using AAS for standard and sample solutions. The method presented in this study is sensitive and suitable for detection at low levels. Furthermore, GF-AAS and F-AAS methods were certificated with standard reference material Trace Elements Whole Blood Level-2 (Ref. Number 201605) for the validation of the analytical methods.

Statistical Analysis

All statistical analysis was performed by SPSS version 16.0 software for Windows. Descriptive statistics comprised of mean, standard deviation, and minimum and maximum values were calculated. Taking into consideration the sample size, parametric tests were performed in order to define significance levels of smoker and non-smoker groups, age groups, and body mass index (BMI) groups. Other than for the significance tests, Pearson correlation was computed for all metals. On the other hand, only one non-parametric test (Mann-Whitney Test) was performed on samples to find significance level with high-risk and low-risk groups. The minimum confidence levels were selected as 95% (p<0.05) and 99% (p<0.01).

Results

The average levels Cd and Pb in whole blood, and average levels of Zn, Cu, and Fe in serum, were found to be 1.27±0.88 µg L-1, 25.1±12.44 µg L-1, 0.97±0.16 mg L-1, 1.10±0.21 mg L-1, and 476.53±42.41 mg L-1, respectively. As presented in Tables 1, 2 and 3, age ranges, the BMI of blood donors, and smoking status were classified into two groups for statistical analysis: for age-adjusted groups, lower than 40 and higher than 40; for BMI, 0-24.99 kg m2 -1 (normal) and higher than 24.99 kg m2 -1 (overweight); and for smoking status, smoker and non-smoker.

Statistically significant association was determined between the smoking and whole blood Cd levels (p<0.01) (Table 1). Sta-

Table 1. Whole blood Cd, Pb and serum Zn, Cu, Fe levels in the smoker and non-smoker groups of Turkish blood donors.

	Cd (µg L^{-1})	Pb (µg L^{-1})	Zn (mg L^{-1})	Cu (mg L^{-1})	Fe (mg L^{-1})
Smoker (n=119)	1.57 ±0.95	25.6 ±12.32	0.96±0.15	1.11 ±0.22	478.5±47.21
Non-smoker (n=92)	0.89 ±0.57	24.5 ±12.62	0.98±0.17	1.09 ±0.19	473.9±35.33
p	<0.01	>0.05	>0.05	>0.05	>0.05
Total (n=211)	1.27 ±0.88	25.1±12.44	0.97±0.16	1.10 ±0.21	476.53±42.41

Results were presented as mean±SD.

Table 2. Whole blood Cd, Pb and serum Zn, Cu, Fe levels in the age groups of Turkish blood donors

	Cd (µg L-1)	Pb (µg L-1)	Zn (mg L-1)	Cu (mg L-1)	Fe (mg L-1)
<40 years (n=164)	1.27 ±0.89	25.08 ±12.31	0.97 ±0.16	1.08 ±0.18	476.55 ±44.11
>40 years (n=47)	1.28 ±0.85	25.31 ±13.00	0.96 ±0.16	1.17 ±0.28	476.47 ±36.24
p	>0.05	>0.05	>0.05	<0.01**	>0.05

Results were presented as mean±SD. n= Number of subjects tistically significant difference was found between the age groups and serum Cu levels ($p<0.01$) (Table 2). Furthermore, correlations were found between age and Cu levels in addition to age and body mass index (BMI) (Pearson correlation, r = 0.19 p<0.01; r = 0.23 p<0.01, respectively). Statistically significant positive correlations were found between Pb and Fe, as well as Zn and Fe (Pearson correlation, r = 0.14 p<0.05; r = 0.44 p<0.01, respectively). There was not any correlation between BMI and other serum metal levels (p>0.05) (Table 3).

Statistically significant associations were found in Pb and Fe levels between the high-risk and low-risk groups (the high-risk group was identified as subjects taking medications, having had an infection within 2 weeks of admission, or hospital personnel) (p < 0.05) (Table 4).

Discussion

Worldwide, various safeguards are used to protect patients from infected blood and blood products. In 2000, the Scientific Committee on Medicinal Products and Medical Devices of European Commission advised that certain criteria be implemented by all member states. Most of the criteria are serological screening tests, such as Hepatitis B surface antigen (HBsAg), Hepatitis C antibody (HCV ab), antibodies against HIV1, and antibodies against HIV2. In the United States, the Centers for Disease Control and Prevention (CDC) have established additional microbiological tests, including Human T-Lymphotrophic Virus Types I and II (HTLV), treponema pallidum, and West Nile Virus (WNV). The Federal Food and Drug Administration (FDA) blood-safety system includes measures concerning donor screening, blood testing, donor lists, quarantine, and related problems [10]. The largest portion of blood collected in blood banks is obtained in hospital units in Turkey. Most of the safety policies in blood banking are based on certain bloodborne pathogens, but toxic metal contamination and overload of essential metals, except for iron, have been omitted. Bulleova et al. [1] reported that 0.5% of the samples had lead levels that exceeded 10 microg/dl, and two samples had lead levels that exceeded 30 microg/dl. The two samples with the highest lead levels could have presented an additional risk to infants if they had been used for blood replacement. For complete blood replacement, it has been estimated that a child weighing up to 12 kg will need 1 L of blood. In this case, even 300 mL of blood at 30-40 µl/dL would raise blood lead levels over the recommended safe levels of the CDC, 2012 [11].

In our study, average levels of Cd, Pb, Zn, Cu, and Fe were found to be 1.27±0.88 µg L-1, 25.1±12.44 µg L-1, 0.97±0.16 mg L-1, 1.10±0.21 mg L-1, and 476.53±42.41 mg L-1, respectively. Heitland P et al. found that 130 subjects had mean 22 µg L-1 Pb levels, consistent with our results [9]. In France, the French Nutrition and Health Survey (ENNS 2006-2007) found the geometric mean of whole blood lead levels in the population to be 2.57 µg dL- [12]. The mean blood lead levels in European countries were 1.65, 2.48, 2.71, 3.10, and 2.40 µg/dL in Belgium, Czech Republic, Denmark, France, and Portugal, respectively [13]. In a study conducted among six hospital employees, the median overall whole blood lead and cadmium concentration were found to be 1.6 µg dL-1 and 0.21 µg dL-1. In the same study, whole blood cadmium was higher in smokers (0.70 µg dL-1) compared to non-smokers (0.13 µg dL-1). Also, a higher whole blood lead level of 38.2 µg dL-1 was obtained from a sixty-year-old healthy hospital employee who each day consumed 30 olives that had been prepared in vinegar in an old earthenware jar. In further analysis, the observers reported finding a whole blood lead concentration of 4.700 µg L-1 in the liquid from the olives [14]. In another study for the assessment of reference ranges for serum copper (Cu) and zinc (Zn) in an Italian population, levels at the 95th percentile (geometric mean, GM) were found to be 776-1495 µg L-1 (1036 µg L-1) and 4686-8585 µg L-1 (6418 µg L-1), respectively [15]. In Germany, biomonitoring of 30 trace elements in the urine of 72 children and 87 adults gave the results of 0.1-4.6 µg L-1 (1.3 µg L-1); 0.03-0.48 µg L-1 (0.16 µg L-1); 4-53 µg L-1 (14 µg L-1); and 60-1142 µg L-1 (482 µg L-1) for whole blood lead, cadmium , serum copper, and zinc, respectively [16].

Table 3. Correlations between age, BMI, and metal levels (Cd and Pb in whole blood; Zn,Cu, and Fe in serum) of the Turkish blood donors

	Cd	Zn	Cu	Fe	Age	BMI
Pb	0,05	0,08	0,09	0,14*	0,04	-0,09
Cd	1	-0,03	0,04	0,11	-0,10	-0,06
Zn		1	0,06	0,44**	-0,02	0,01
Cu			1	0,04	0,19**	-0,04
Fe				1	-0,05	-0,02
Age					1	0,23**
BMI						1

Conclusion

This is an original study for assessment of average levels for whole blood Cd, Pb and serum Zn, and Fe in a Turkish population. It emphasizes the importance of determining toxic heavy metals in blood donations intended for specific populations, such as children and thalassemia patients. Especially for those countries that have inspection capability in industrialized areas, blood donations should be carefully monitored for toxic heavy metals.

Table 4. Whole blood Cd, Pb and serum Zn, Cu, Fe levels in the high-risk and low-risk groups of Turkish blood donors

	Cd (µg L-1)	Pb (µg L-1)	Zn (mg L-1)	Cu (mg L-1)	Fe (mg L-1)
Low-risk group (n=193)	1.25 ±0.87	24.66 ±12.39	0.97 ±0.15	1.10 ±0.21	475.75 ±37.84
High-risk group (n=18)	1.47 ±0.95	30.27 ±12.14	0.92 ±0.20	1.05 ±0.13	484.93 ±77.17
p	>0.05	<0.05*	>0.05	>0.05	<0.05*

Results were presented as mean±SD. n= Number of subjects

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Conflict of Interest

The authors have no conflict of interest.

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